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(54) **LAUNDRY TREATING APPLIANCE WITH IMAGING CONTROL**

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(51) **Int. Cl.**

F26B 13/10	(2006.01)
G06K 9/00	(2006.01)
D06F 58/28	(2006.01)
D06F 58/04	(2006.01)

(52) **U.S. Cl.**

CPC ***D06F 58/28*** (2013.01); ***D06F 58/04*** (2013.01); *D06F 2058/2803* (2013.01); *D06F 2058/2854* (2013.01)

(58) **Field of Classification Search**

CPC . D06F 58/28; D06F 58/04; D06F 2058/2854; D06F 2058/2861

USPC 34/524, 603; 356/914; 382/107, 111; 116/213

See application file for complete search history.

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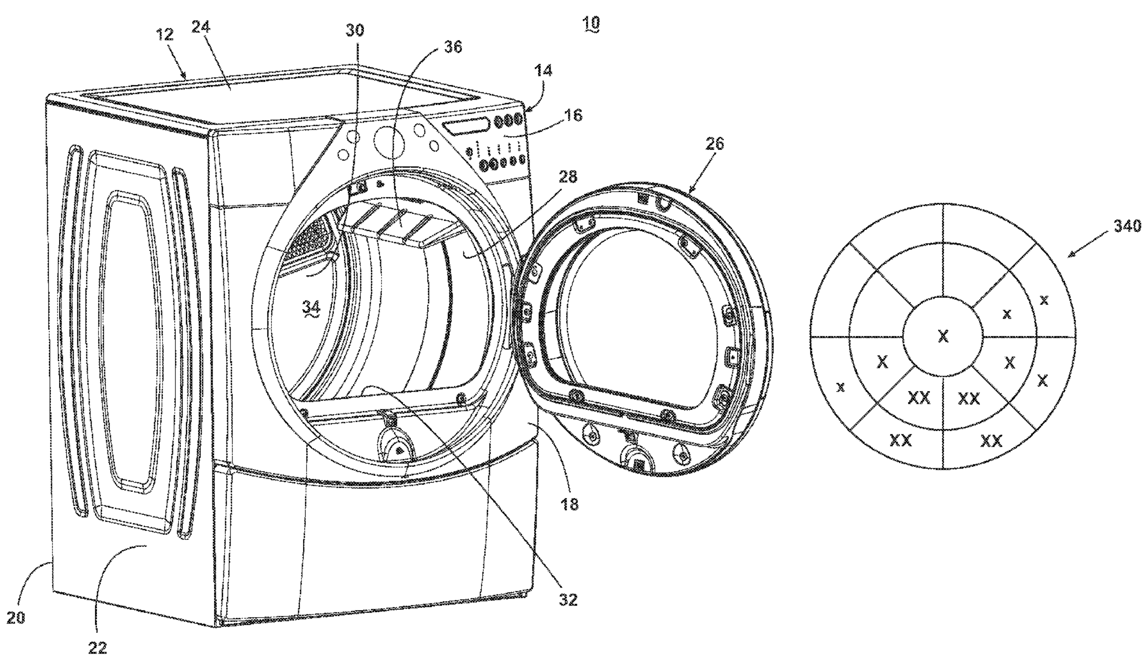
(57) **ABSTRACT**

A laundry treating appliance having a rotatable drum defining a laundry treating chamber, where the laundry in the laundry treating chamber may be imaged and a motion condition of the laundry determined based on the imaging of the laundry. The operation of the laundry treating appliance may be based on the determined motion condition.

38 Claims, 11 Drawing Sheets



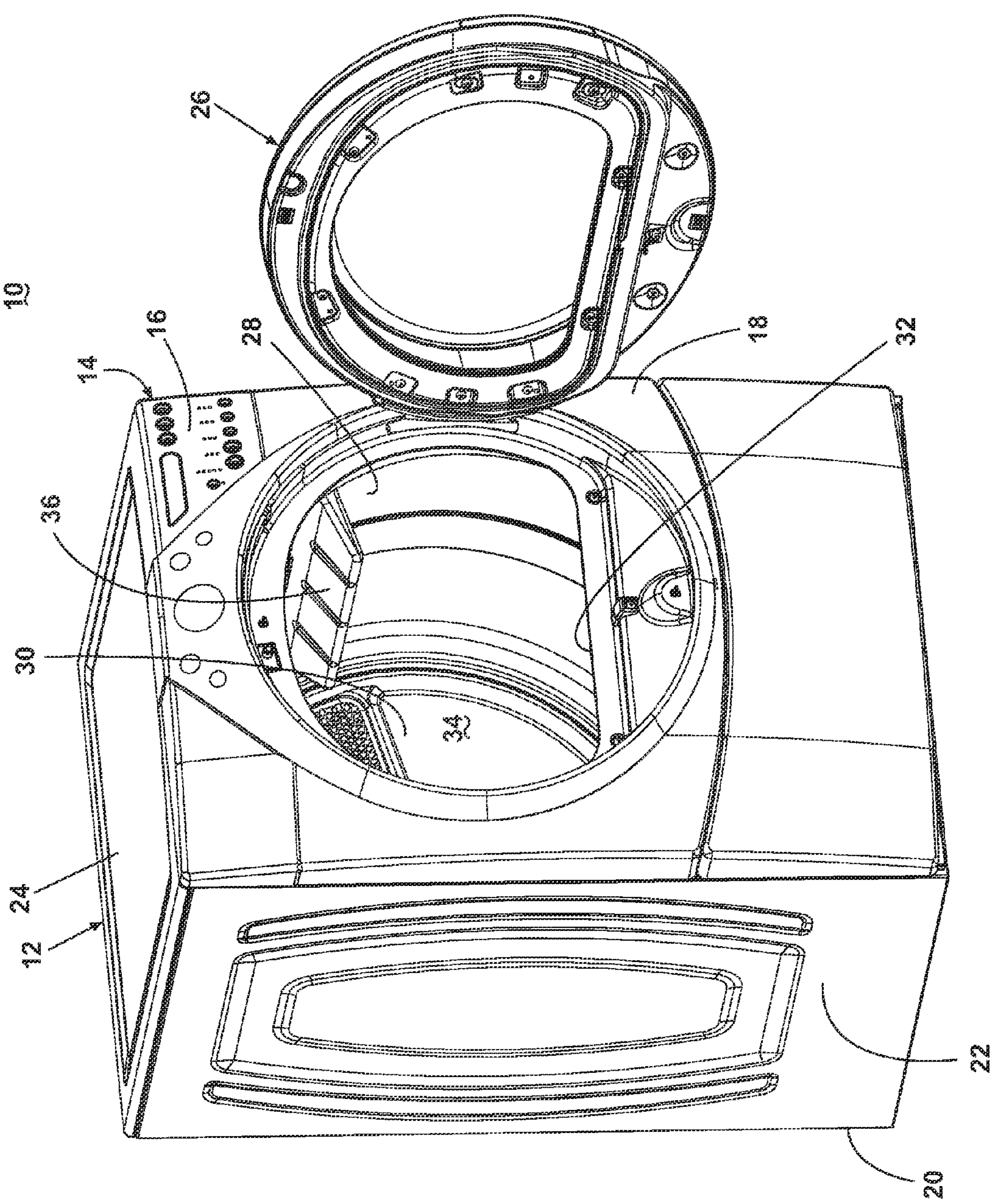


Fig. 1

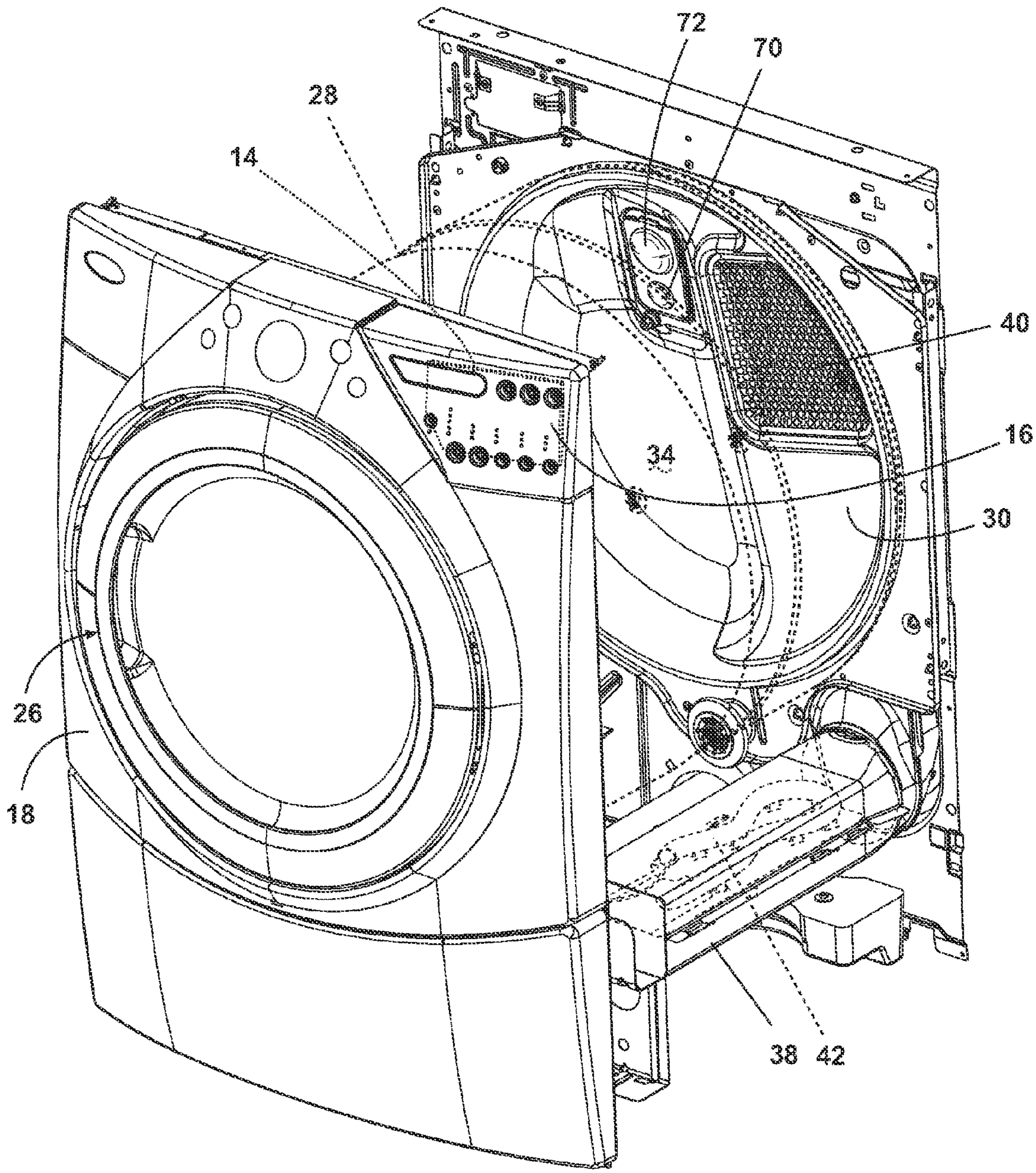


Fig. 2

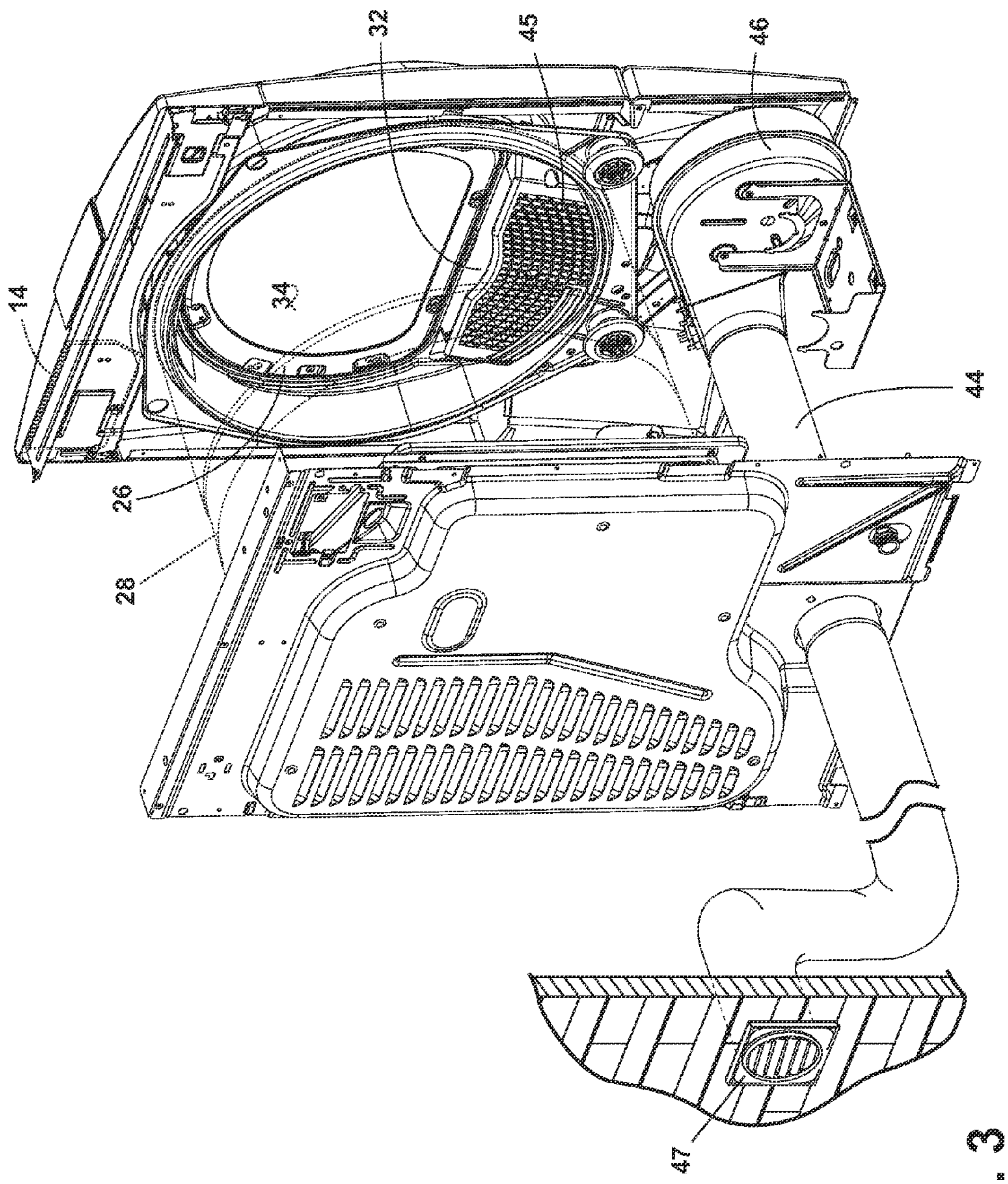


Fig. 3

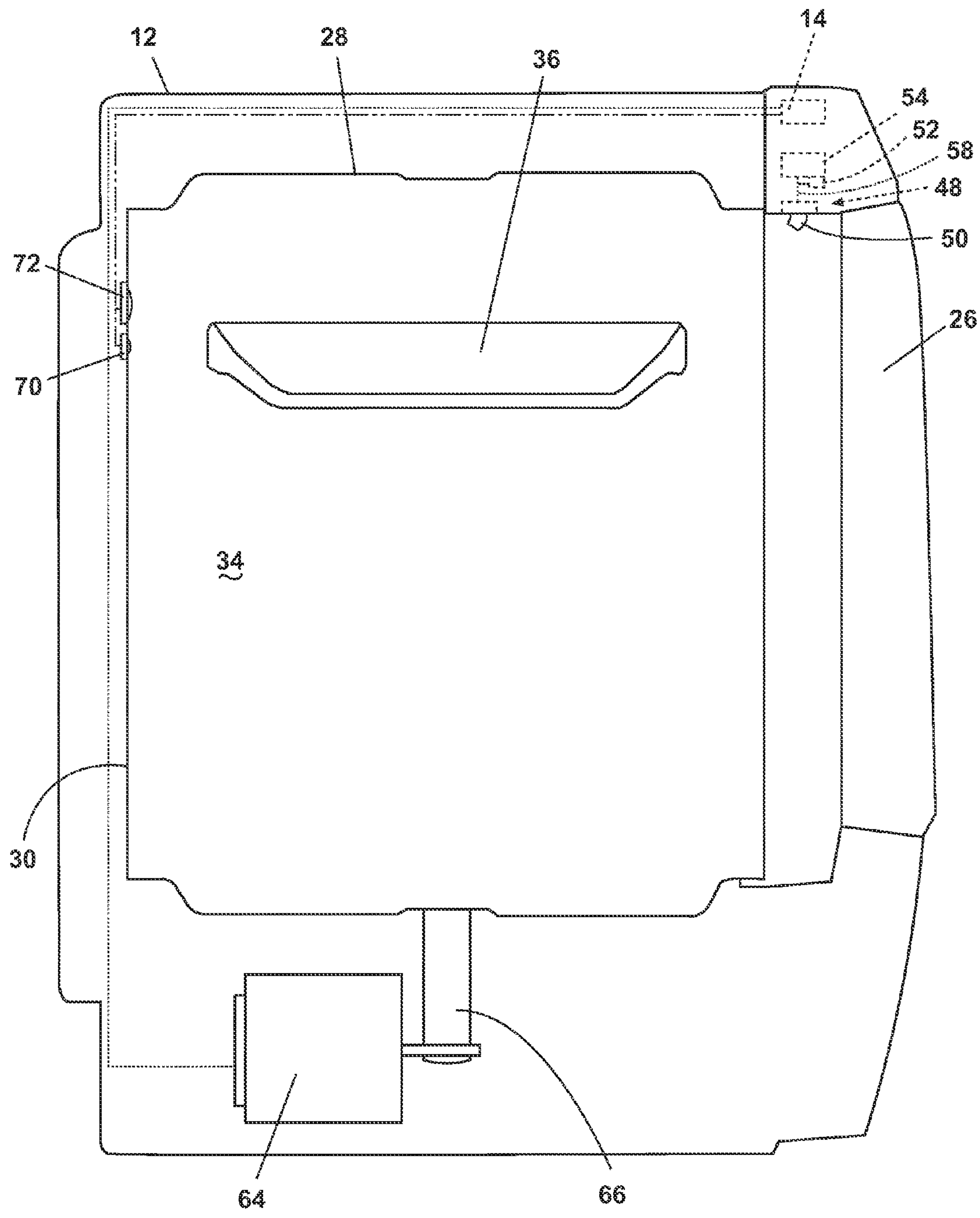


Fig. 4

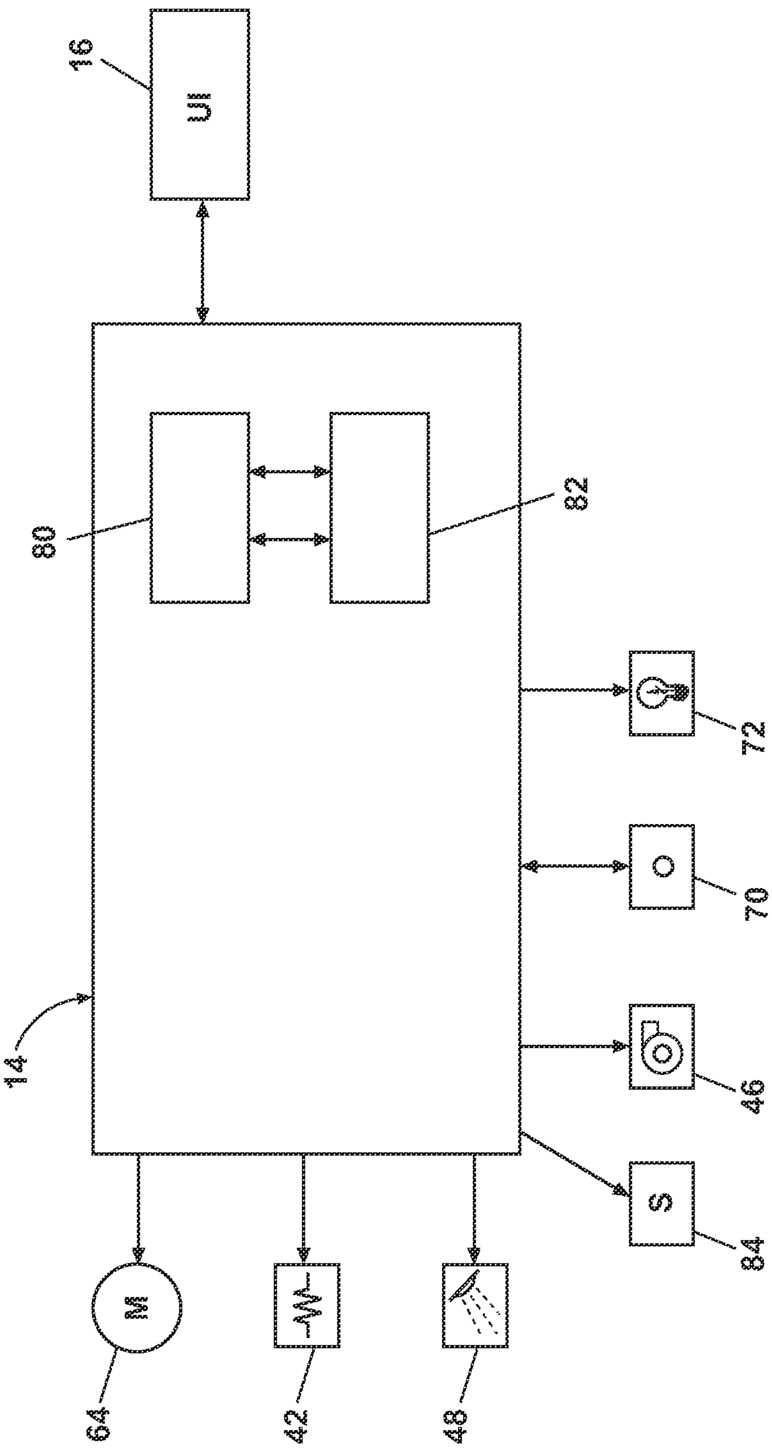


Fig. 5

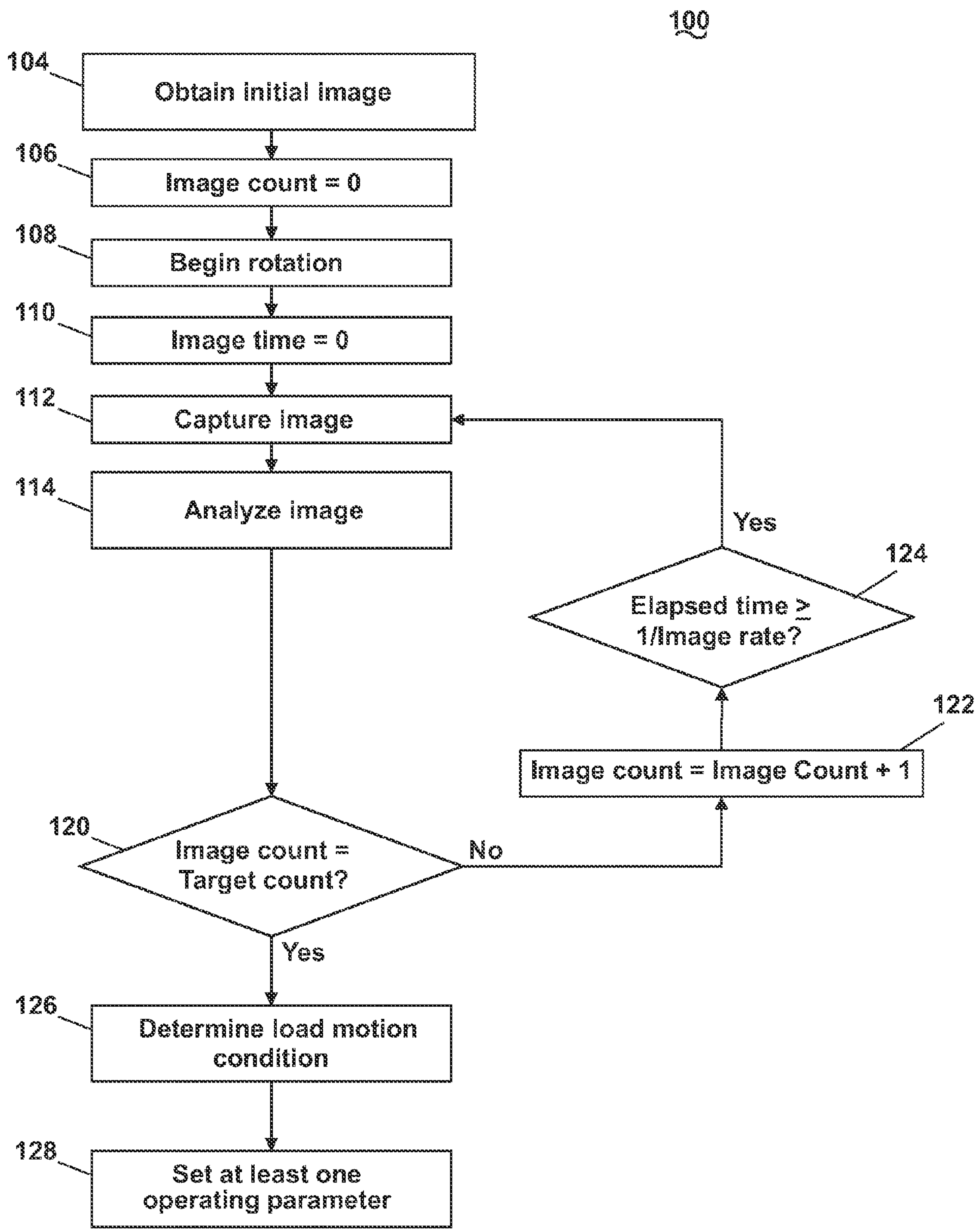

100
104
Obtain initial image
106
Image count = 0
108
Begin rotation
110
Image time = 0
112
Capture image
114
Analyze image
Yes
124
Elapsed time ≥ 1/Image rate?
122
Image count = Image Count + 1
120
Image count = Target count?
No
Yes
126
Determine load motion condition
128
Set at least one operating parameter

Fig. 6

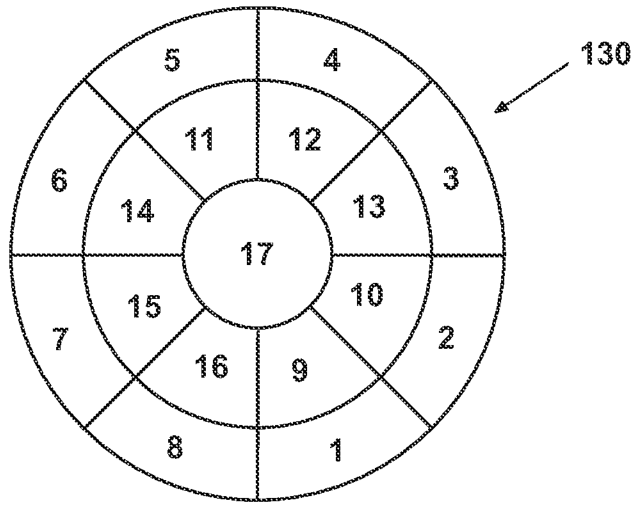


Fig. 7

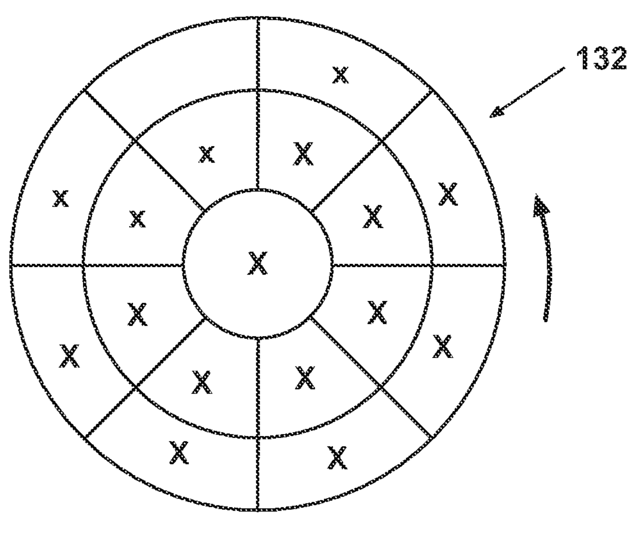


Fig. 8

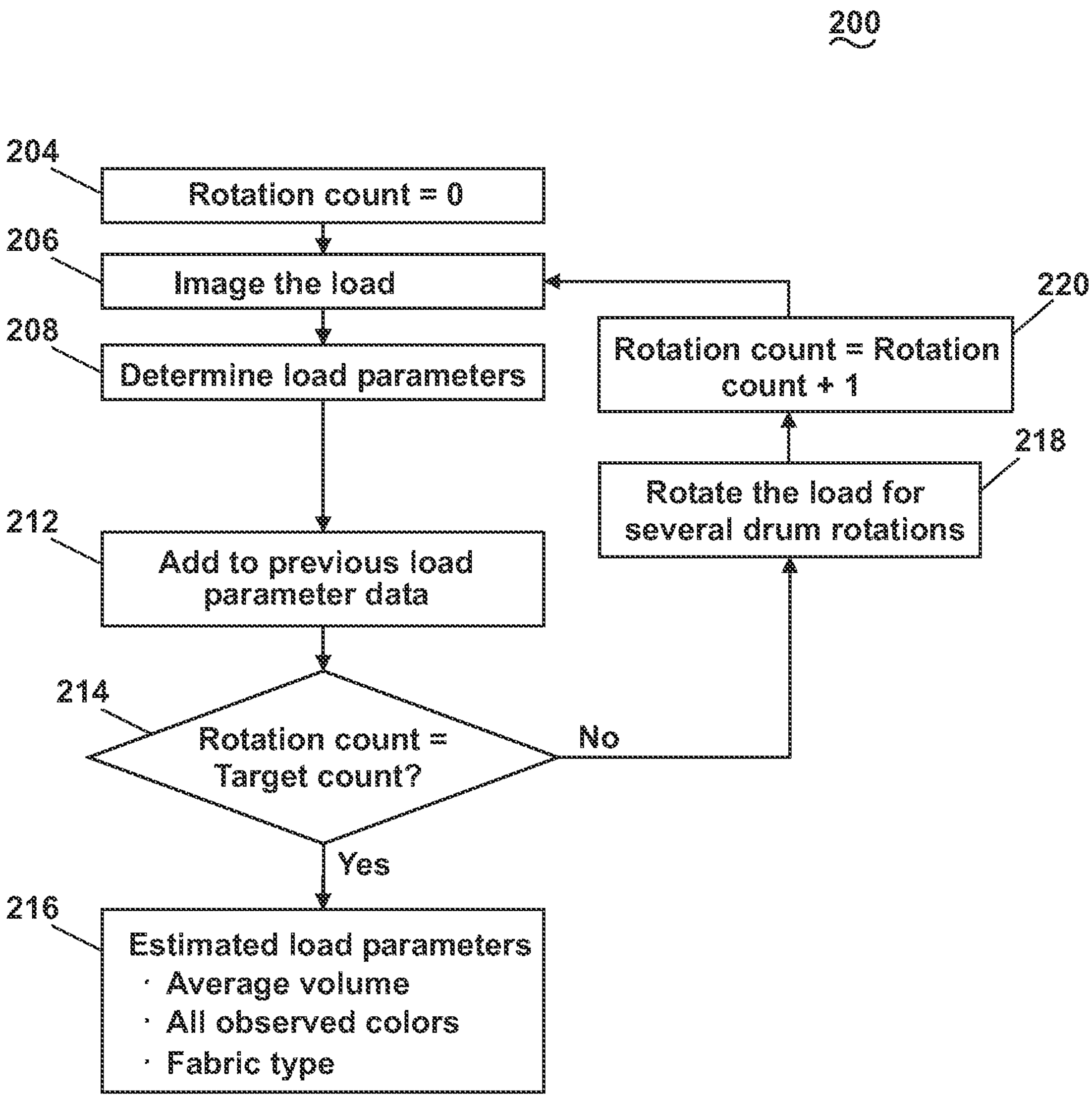

200
204
Rotation count = 0
206
Image the load
208
Determine load parameters
212
Add to previous load parameter data
214
Rotation count = Target count?
No
Yes
216
Estimated load parameters
· Average volume
· All observed colors
· Fabric type
218
Rotate the load for several drum rotations
220
Rotation count = Rotation count + 1

Fig. 9

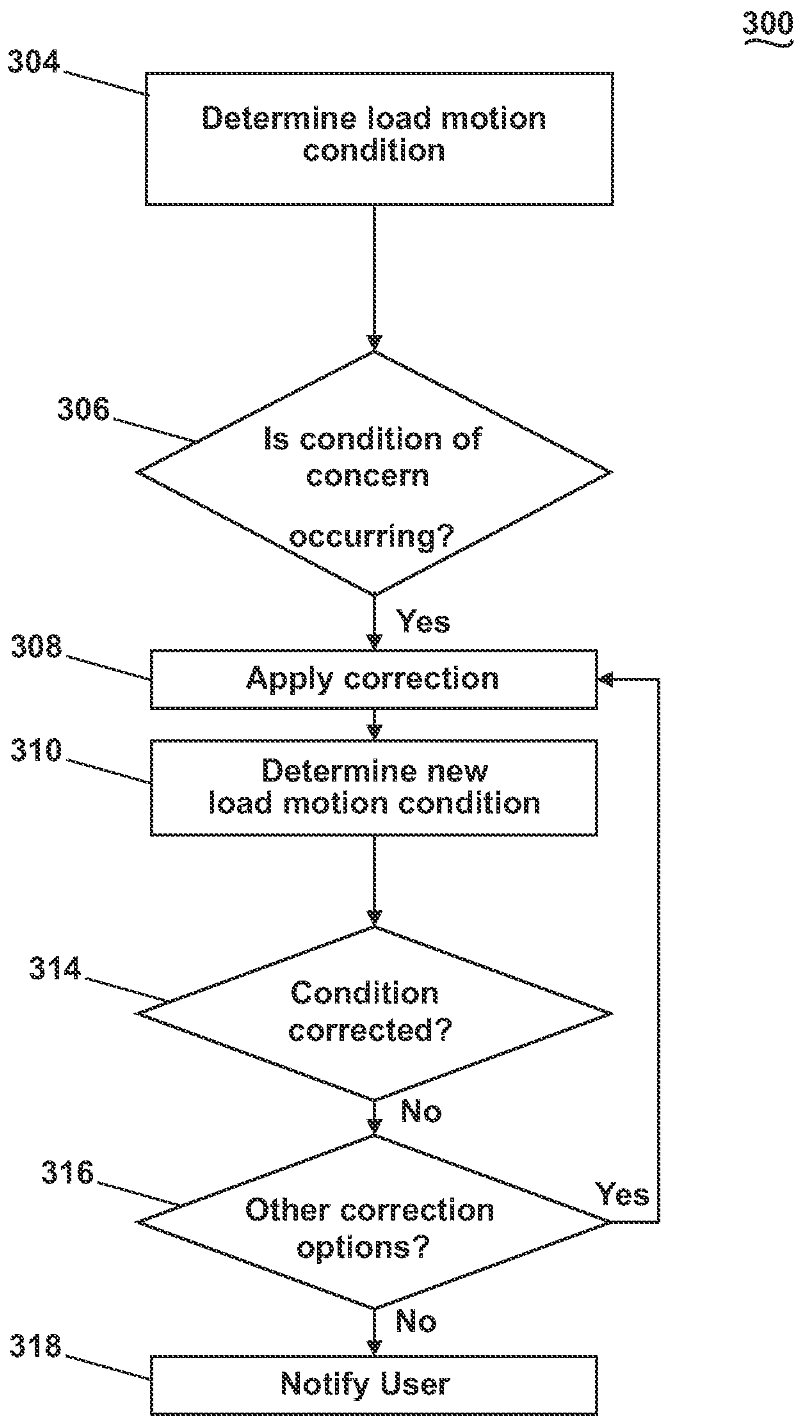

300
304
Determine load motion condition
306
Is condition of concern occurring?
Yes
308
Apply correction
310
Determine new load motion condition
314
Condition corrected?
No
316
Other correction options?
Yes
No
318
Notify User

Fig. 10

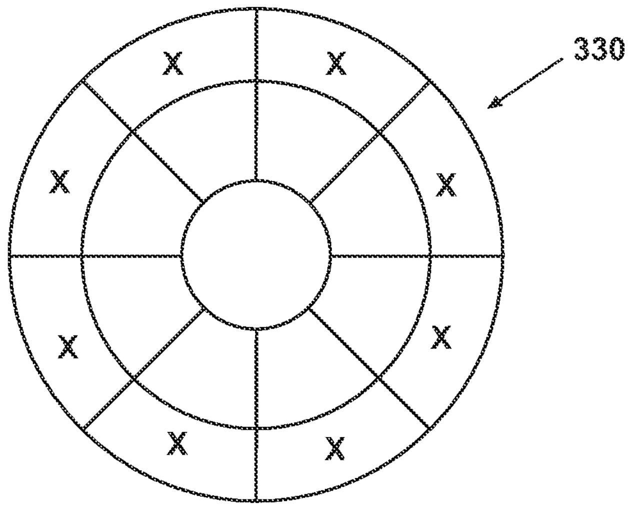


Fig. 11

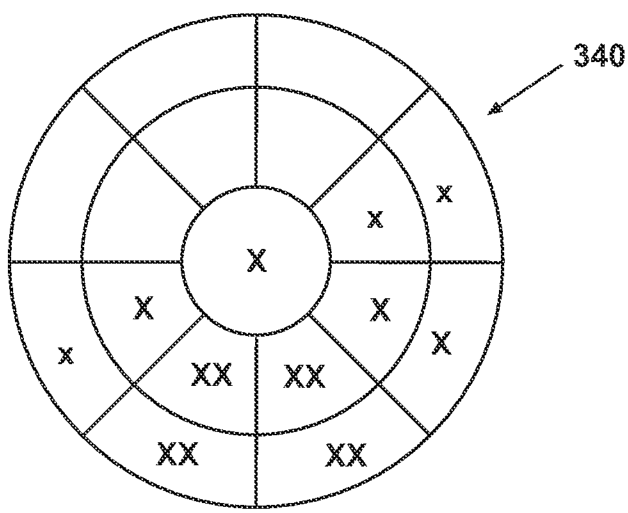


Fig. 12

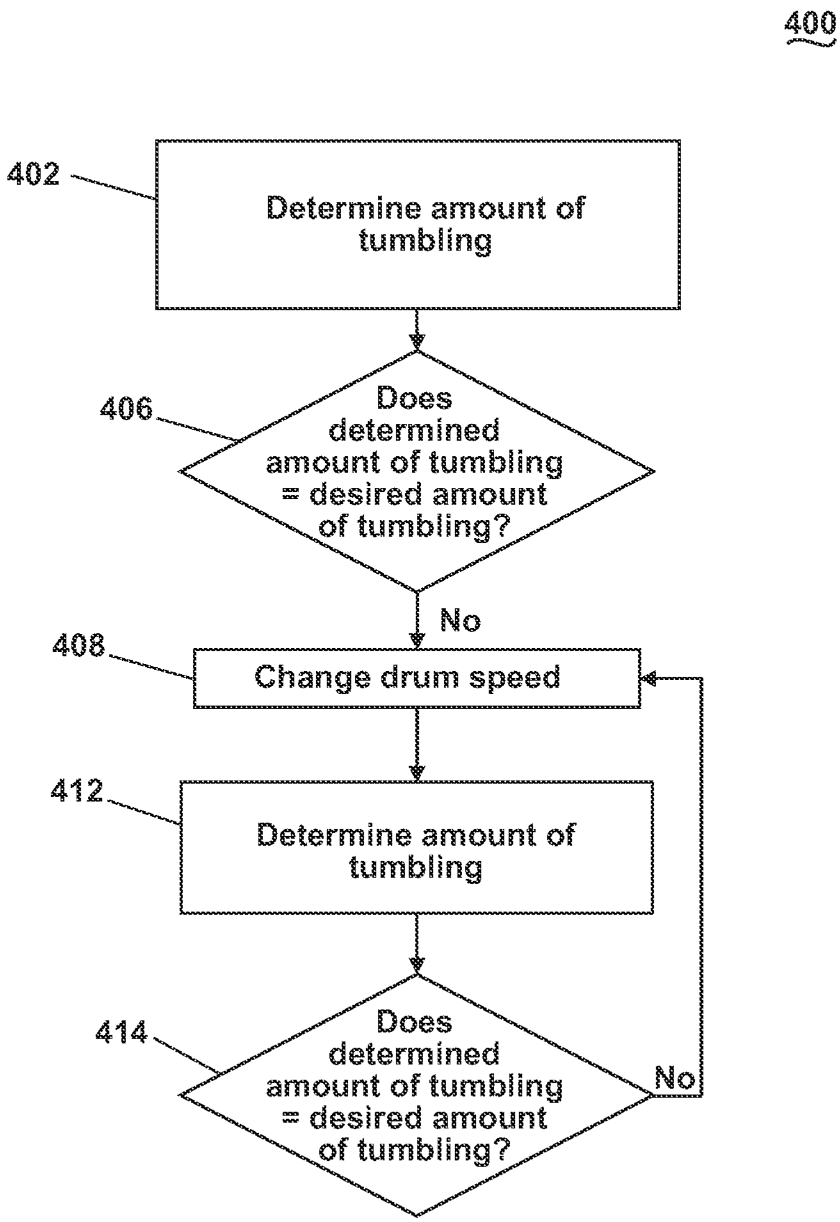

400
402
Determine amount of tumbling
406
Does determined amount of tumbling = desired amount of tumbling?
No
408
Change drum speed
412
Determine amount of tumbling
414
Does determined amount of tumbling = desired amount of tumbling?
No

Fig. 13

LAUNDRY TREATING APPLIANCE WITH IMAGING CONTROL

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 12/388,605, filed Feb. 19, 2009, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Laundry treating appliances, such as clothes washers, clothes dryers, refreshers, and non-aqueous systems, may have a configuration based on a rotating drum that defines a treating chamber in which laundry items are placed for treating. The laundry treating appliance may have a controller that implements a number of pre-programmed cycles of operation. The user typically manually selects the cycle of operation from the given pre-programmed cycles. Each pre-programmed cycle may have any number of adjustable parameters, which may be input by the user or may be set by the controller. The controller may set the parameter according to default values, predetermined values, or responsive to conditions within the treating chamber.

SUMMARY OF THE INVENTION

The invention relates to a method of operating a laundry treating appliance having a rotatable drum defining a laundry treating chamber. The laundry in the laundry treating chamber may be imaged and a motion condition of the laundry determined based on the imaging of the laundry. The operation of the laundry treating appliance may be based on the determined motion condition.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a front perspective view of a laundry treating appliance in the form of a clothes dryer with a treating chamber according to one embodiment of the invention.

FIG. **2** is a partial perspective view of the dryer of FIG. **1** with portions of the cabinet removed for clarity according to one embodiment of the invention.

FIG. **3** is second partial perspective view of the dryer of FIG. **1** with portions of the cabinet removed for clarity according to one embodiment of the invention.

FIG. **4** is a schematic side view of the dryer of FIG. **1** having an imaging system for imaging the treating chamber according to one embodiment of the invention.

FIG. **5** is a schematic representation of a controller for controlling the operation of one or more components of the clothes dryer of FIG. **1** according to one embodiment of the invention.

FIG. **6** is a flow chart illustrating a method for capturing and analyzing images of the treating chamber according to a second embodiment of the invention.

FIG. **7** is a schematic representation of a grid for analyzing an image of the treating chamber according to the second embodiment of the invention.

FIG. **8** is a schematic representation of an image of the treating chamber illustrating a tumbling motion condition according to the second embodiment of the invention.

FIG. **9** is a flow chart illustrating a method for capturing an image of the treating chamber and estimating load parameters based on the captured image according to a third embodiment of the invention.

FIG. **10** is a flow chart illustrating a method for determining if a condition of concern exists in the treating chamber and applying a corrective action according to a fourth embodiment of the invention.

FIG. **11** is a schematic representation of an image of the treating chamber illustrating a satelliting motion condition according to a fifth embodiment of the invention.

FIG. **12** is a schematic representation of an image of the treating chamber illustrating a sliding motion condition according to a sixth embodiment of the invention.

FIG. **13** is a flow chart illustrating a method for altering the speed of rotation of a dryer drum to obtain a desired amount of tumbling according to a seventh embodiment of the invention.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

FIG. **1** illustrates one embodiment of a laundry treating appliance in the form of a clothes dryer **10** according to the invention. While the laundry treating appliance is illustrated as a clothes dryer **10**, the laundry treating appliance according to the invention may be any appliance which performs a cycle of operation on laundry, non-limiting examples of which include a horizontal or vertical axis clothes washer; a combination washing machine and dryer; a tumbling or stationary refreshing/revitalizing machine; an extractor; a non-aqueous washing apparatus; and a revitalizing machine. The clothes dryer **10** described herein shares many features of a traditional automatic clothes dryer, which will not be described in detail except as necessary for a complete understanding of the invention.

As illustrated in FIG. **1**, the clothes dryer **10** may include a cabinet **12** in which is provided a controller **14** that may receive input from a user through a user interface **16** for selecting a cycle of operation and controlling the operation of the clothes dryer **10** to implement the selected cycle of operation.

The cabinet **12** may be defined by a front wall **18**, a rear wall **20**, and a pair of side walls **22** supporting a top wall **24**. A door **26** may be hingedly mounted to the front wall **18** and may be selectively moveable between opened and closed positions to close an opening in the front wall **18**, which provides access to the interior of the cabinet.

A rotatable drum **28** may be disposed within the interior of the cabinet **12** between opposing stationary rear and front bulkheads **30** and **32**, which collectively define a treating chamber **34**, for treating laundry, having an open face that may be selectively closed by the door **26**. Examples of laundry include, but are not limited to, a hat, a scarf, a glove, a sweater, a blouse, a shirt, a pair of shorts, a dress, a sock, a pair of pants, a shoe, an undergarment, and a jacket. Furthermore, textile fabrics in other products, such as draperies, sheets, towels, pillows, and stuffed fabric articles (e.g., toys), may be dried in the clothes dryer **10**.

The drum **28** may include at least one lifter **36**. In most dryers, there are multiple lifters. The lifters **36** may be located along the inner surface of the drum **28** defining an interior circumference of the drum **28**. The lifters **36** may facilitate movement of the laundry within the drum **28** as the drum **28** rotates.

As illustrated in FIG. **2**, the dryer **10** may also be provided with a light source **33** in either the rear or front bulkheads **30**, **32** for illuminating the contents of the treating chamber **34**.

Still referring to FIG. **2**, an air flow system for the clothes dryer **10** according to one embodiment of the invention will now be described. The air flow system supplies air to the treating chamber **34** and then exhausts air from the treating chamber **34**. The supplied air may be heated or not. The air flow system may have an air supply portion that may be formed in part by an inlet conduit **38**, which has one end open to the ambient air and another end fluidly coupled to an inlet grill **40**, which may be in fluid communication with the treating chamber **34**. A heating element **42** may lie within the inlet conduit **38** and may be operably coupled to and controlled by the controller **14**. If the heating element **42** is turned on, the supplied air will be heated prior to entering the drum **28**.

Referring to FIG. **3**, the air supply system may further include an air exhaust portion that may be formed in part by an exhaust conduit **44** and lint trap **45**, which are fluidly coupled by a blower **46**. The blower **46** may be operably coupled to and controlled by the controller **14**. Operation of the blower **46** draws air into the treating chamber **34** as well as exhausts air from the treating chamber **34** through the exhaust conduit **44**. The exhaust conduit **44** may be fluidly coupled with a household exhaust duct **47** or exhausting the air from the drying chamber to the outside.

Referring now to FIG. **4**, the clothes dryer **10** may optionally have a dispensing system **48** for dispensing treating chemistries, including without limitation water or steam, into the treating chamber **34**, and thus may be considered to be a dispensing dryer. The dispensing system **48** may include a reservoir **54** capable of holding treating chemistry and a dispenser **50** that fluidly couples with the reservoir **54** through a dispensing line **58**. The treating chemistry may be delivered to the dispenser **50** from the reservoir **54** and the dispenser **50** may dispense the chemistry into the treating chamber **34**. The dispenser **50** may be positioned to direct the treating chemistry at the inner surface of the drum **28** so that laundry may contact and absorb the chemistry, or to dispense the chemistry directly onto the laundry in the treating chamber **34**. The type of dispenser **50** is not germane to the invention. A chemistry meter **52** may electronically couple, wired or wirelessly, to the controller **14** to control the amount of treating chemistry dispensed.

As is typical in a clothes dryer, the drum **28** may be rotated by a suitable drive mechanism, which is illustrated as a motor **64** and a coupled belt **66**. The motor **64** may be operably coupled to the controller **14** to control the rotation of the drum **28** to complete a cycle of operation. Other drive mechanisms, such as direct drive, may also be used.

The clothes dryer **10** may also have an imaging device **70** to image the treating chamber **34** and/or anything within the treating chamber **34**. Exemplary imaging devices **70** may include any optical sensor capable of capturing still or moving images, such as a camera. One suitable type of camera is a CMOS camera. Other exemplary imaging devices include a CCD camera, a digital camera, a video camera or any other type of device capable of capturing an image. That camera may capture either or both visible and non-visible radiation. For example, the camera may capture an image using visible light. In another example, the camera may capture an image using non-visible light, such as ultraviolet light. In yet another example, the camera may be a thermal imaging device capable of detecting radiation in the infrared region of the electromagnetic spectrum. The imaging device **70** may be located on either of the rear or front bulkhead **30**, **32** or in the door **26**. It may be readily understood that the location of the imaging device **70** may be in numerous other locations depending on the particular structure of the dryer and the desired position for obtaining an image. There may also be multiple imaging devices, which may image the same or different areas of the treating chamber **34**.

The clothes dryer **10** may also have an illumination source **72**. The type of illumination source **72** may vary. In one configuration, the illumination source **72** may be a typical incandescent dryer light which is commonly used to illuminate the treating chamber **34**. Alternatively, one or more LED lights may be used in place of an incandescent bulb. The illumination source **72** may also be located behind the rear bulkhead **30** of the drum **28** such that the light shines through the holes of the air inlet grill **40**. It is also within the scope of the invention for the clothes dryer **10** to have more than one illumination source **72**. For example, an array of LED lights may be placed at multiple positions in either bulkhead **30**, **32**.

The illumination source **72** may be located on the same side of the drum **28** as the imaging device **70**, as illustrated in FIG. **4**, or located on a different side of the drum **28**. When the illumination source **72** is located on the same side of the drum **28** as the imaging device **70**, the imaging device **70** may detect the light that may be reflected by the drum **28** and the laundry load. Image analysis may then be used to separate the drum **28** from the laundry load. When the illumination source **72** is located on a side of the drum **28** opposite the imaging device **70**, the imaging device **70** detects only the light from the illumination source **72** that is not blocked by the laundry load. At any instant in time, a given location in an image will be dark or light depending on whether or not laundry is present at that location.

The illumination generated by the illumination source **72** may vary, and may well be dependent on the type of imaging device **70**. For example, illumination may be infrared if the imaging device **70** is configured to image in the infrared spectrum. Similarly, the illumination may be visible light, if the imaging device **70** is configured to image the visible spectrum.

As illustrated in FIG. **5**, the controller **14** may be provided with a memory **80** and a central processing unit (CPU) **82**. The memory **80** may be used for storing the control software that may be executed by the CPU **82** in completing a cycle of operation using the clothes dryer **10** and any additional software. The memory **80** may also be used to store information, such as a database or table, and to store data received from the one or more components of the clothes dryer **10** that may be communicably coupled with the controller **14**.

The controller **14** may be communicably and/or operably coupled with one or more components of the clothes dryer **10** for communicating with and controlling the operation of the component to complete a cycle of operation. For example, the controller **14** may be coupled with the heating element **42** and the blower **46** for controlling the temperature and flow rate through the treatment chamber **34**; the motor **64** for controlling the direction and speed of rotation of the drum **28**; and the dispensing system **48** for dispensing a treatment chemistry during a cycle of operation. The controller **14** may also be coupled with the user interface **16** for receiving user selected inputs and communicating information to the user.

The controller **14** may also receive input from various sensors **84**, which are known in the art and not shown for simplicity. Non-limiting examples of sensors **84** that may be communicably coupled with the controller **14** include: a treating chamber temperature sensor, an inlet air temperature sensor, an exhaust air temperature sensor, a moisture sensor, an air flow rate sensor, a weight sensor, and a motor torque sensor.

The controller **14** may also be coupled with the imaging device **70** and illumination source **72** to capture one or more images of the treating chamber **34**. The captured images may be sent to the controller **14** and analyzed using analysis software stored in the controller memory **80** to determine a motion condition of the laundry. The controller **14** may use the determined motion condition to set one or more operating parameters of at least one component with which the controller **14** is operably coupled with to complete a cycle of operation. The determined motion condition of the laundry may include at least one of tumbling, rolling (also called balling), sliding, satelliting (also called plastering) and any combination thereof.

The terms tumbling, rolling, sliding and satelliting are terms of art that may be used to describe the motion of some or all of the items forming the laundry load. However, not all of the items forming the laundry load need exhibit the motion for the laundry load to be described accordingly.

A brief description of each motion will be useful in understanding the term. Tumbling is a condition in which the laundry may be lifted by the rotating drum from a lower position, generally near or at the bottom of the drum, to a raised position, above the lower position, where the laundry is no longer being lifted by the drum and falls within the drum, generally toward the bottom of the drum. While falling, the laundry may be exposed to any drying air and/or treatment within the drum. The falling may spread out the laundry, increasing its effective surface area, to expose a greater portion of the laundry to any drying air and/or treatment being applied. This phenomenon may increase the rate at which the laundry dries and maximize the interaction between the laundry and the treatment. Examples of treatments that may be applied include steam, mist or a chemistry treatment.

Rolling is a condition in which the laundry may not be lifted by the drum as the drum rotates, such as occurs during tumbling, but rolls or rotates while part of the laundry may still be in contact with the drum lifter. In this condition, a frictional force may be present that causes the laundry to move in a rolling or folding manner with little or no motion above its horizontal position in the drum. Rolling may occur with laundry items that are too large or heavy to be lifted by the drum or when a laundry item becomes entangled with another item. Because the laundry remains concentrated near the bottom of the drum, exposure of the laundry to the drying air and/or treatment may be minimized. This may result in incomplete drying of the laundry and non-uniform application of the treatment.

Sliding is another condition in which the laundry may not be lifted by the drum as the drum rotates, such as occurs during tumbling, but may remain at or near the bottom of the drum. Sliding differs from rolling in that the laundry does not move in a rolling or folding manner, rather, it slides off the inner surface of the drum as the drum rotates, generally exposing the same face of the laundry to the drying air and/or treatment. This may result in incomplete drying of the laundry and non-uniform application of the treatment.

Satelliting is a condition in which the laundry may be held by centrifugal force against the inner surface of the drum as the drum rotates. When satelliting occurs in a clothes dryer, exposure of the laundry to the drying air and/or treatment may be minimized, because the laundry remains at a fixed location relative to the drum, which may result in incomplete drying of the laundry and non-uniform application of the treatment.

The previously described clothes dryer **10** provides the structure necessary for the implementation of the method of the invention. Several embodiments of the method will now be described in terms of the operation of the clothes dryer **10**. The embodiments of the method function to automatically determine the motion state of the laundry and control the operation of the clothes dryer **10** based on the determined motion state.

The motion state of the laundry may be determined by using the imaging device **70** to obtain one or more images over time of the contents of the drum **28** as it is rotating. For some motion states, a single image may be all that needs to be analyzed. For other motion states, multiple images over time may need to be analyzed. The motion state of the laundry may then be used to control the operation of the clothes dryer **10**.

Controlling the operation of the clothes dryer **10** based on the determined motion state may include setting at least one parameter of a cycle of operation including a rotational speed of the drum **28**, a direction of rotation of the drum **28**, a temperature in the treating chamber **34**, an air flow through the treating chamber **34**, a type of treating chemistry, an amount of treating chemistry, a start or end of cycle condition and a start or end cycle step condition.

Setting a start or end of cycle condition may include determining when to start or end a cycle of operation. This may include signaling the controller **14** to immediately start or end a cycle of operation or setting a time at which to start or end a cycle of operation.

Setting a start or end of cycle step condition may include determining when to start a step or phase within a given operating cycle or when to end a step within a given operating cycle. This may include signaling the controller **14** to immediately transition from one cycle step to another or setting a time at which to transition from one step to another within a given operating cycle. Examples of cycle steps include rotation with heated air, rotation without heated air, treatment dispensing and a wrinkle guard step.

For laundry treating appliances other than clothes dryers, parameters of a cycle of operation that may be set based on the determined motion state may also include a rotational speed of an agitator, a direction of agitator rotation, and a wash liquid fill level.

Referring to FIG. **6**, a flow chart of one method **100** of determining the motion of a load of laundry is shown in accordance with the present invention. The motion determining method **100** may be executed by the controller **14** during a drying or treatment cycle of the clothes dryer **10**. The sequence of steps depicted is for illustrative purposes only, and is not meant to limit the motion determining method **100** in any way as it is understood that the steps may proceed in a different logical order or additional or intervening steps may be included without detracting from the invention.

The method **100** starts with assuming that the user has loaded the clothes dryer **10** with one or more articles to form the laundry load and closed the door **26**. The method **100** may be initiated automatically when the user closes the door **26** or at the start of a user selected operating cycle. Step **104** is an optional step in which the controller **14** obtains an initial image of the laundry load without rotation of the drum. While not germane to this invention, the initial image may be used to determine load parameters such as the volume of the load or fabric type of the load, for example.

In the next step **106**, a counter Image Count is set to 0 and rotation of the drum **28** is initiated at **108**. The speed of rotation of the drum **28** may be increased until it reaches a predetermined speed of rotation. The predetermined speed of rotation may be determined by the controller **14** based on the selected operating cycle and the operating parameter settings. When the drum speed reaches the predetermined speed, the image time may be set to 0 at step **110** and the imaging device **70** may capture an image of all or some portion of the treating chamber **34**. The captured image may be sent to the controller **14** for image analysis using software that is stored in the memory **80** of the controller **14**.

It is also within the scope of the invention for the imaging device **70** to have a memory and a microprocessor for storing information and software and executing the software, respectively. In this manner, the imaging device **70** may analyze the captured image data and communicate the results of the analysis with the controller **14**.

In step **114**, analyzing the image may include separating the load image from the background, i.e. the dryer drum **28**, in the image captured in step **112**. Any suitable method may be used to separate the load from the background in the image. There are several methods for separating the load image from the background depending on the illumination configuration, drum properties and the load. Once the load image is separated from the background, an image of the treating chamber **34** may be created wherein each pixel in the image indicates the presence or absence of the load. The image separation techniques may also be used to separate one load item from another.

For example, in the case of an illumination configuration where the illumination source **72** may be located on the same side of the drum **28** as the imaging device **70**, techniques such as edge detection, color segmentation and deviation from a known background image may be used to separate the load from the background. Edge detection may be calculated using known methods. Color segmentation involves separating the individual items in a load from each other and separating the load from the background based on differences in the saturation, hue and luminance of objects in the image. The surface of the dryer drum **28** may also contain optically detectable features to aid in the separation of the load from the background image of the drum **28**.

In the case of an illumination configuration in which the load may be back lit from an illumination source **72** located on a portion of the drum **28** opposite from the imaging device **70**, separation of the load from the background may be more simplified. The areas in which a load is present will appear black or dark in the image, since light from the illumination source **72** is blocked by the load. In places where the load is not present, the light from the illumination source may be detected by the imaging device **70**.

Regardless of how the load image is separated from the background in step **114**, the images captured by the imaging device **70** may be used to obtain information relating to the shape and location of the laundry load relative to the drum **28**. For example, the image may be used to calculate the area, perimeter, center of mass, radius and major or minor axis of the load using known methods. The image may also be used to determine the motion of the load relative the drum **28**. One method for determining the position or motion of the load is to build a segmentation map from the captured image of the treating chamber **34**.

A segmentation map may be created by dividing the image space into fixed segments and then determining the fraction of the area of each segment in which the load is present. The load position at any instant in time may be characterized by the percent coverage of the load in each segment. The percent coverage is the percentage of pixels in the image where the load is present. The position of the load at a given instant in time may be determined by the percent coverage in each segment at that instant in time. The motion of the load may be determined by integrating the percent coverage over multiple revolutions of the drum **28**.

The segmentation map created in step **114** may be stored in the memory associated with the imaging device **70** or with the controller **14**. The stored segmentation maps may be used to create a database from which a load motion segmentation map may be determined by integrating the percent coverage of each segment over time as described above.

In the next step **120**, the controller **14** determines if the image count equals the target count. If the image count is less than the target count, the image count may be increased by 1 in step **122**. If the elapsed time in step **124** is determined to be equal to or greater than one divided by the imaging rate, the method returns to step **112** and steps **112** through **120** may be repeated.

The target image count in step **120** may be selected such that a sufficient number of images may be captured and analyzed to determine the motion condition of the load. The image rate may be selected such that a predetermined number of images may be captured within a predetermined amount of time. The predetermined amount of time for capturing images for analysis may be set such that the motion condition may be determined and corrected, if necessary, within a suitable amount of time to avoid or minimize undesirable conditions such as sliding, rolling and satelliting of the load.

If the image count equals the target count, then the load motion condition may be determined in step **126** by integrating the percent coverage in each segment of each segmentation map created in step **114** from the images treating chamber **34**. The integrated percent coverage in each segment may be used to create an integrated segmentation map wherein the value in each segment correlates to the amount of time laundry is present in that segment. The determined integration segmentation map may be analyzed using pattern recognition techniques to determine if the segmentation map corresponds to a known motion condition. Pattern recognition may be used to determine if all of the load or some part of the load is exhibiting a motion state consistent with a known condition.

In step **128**, the determined load motion condition may be used by the controller **14** to set one or more parameters of a cycle of operation including a rotational speed of the drum **28**, a direction of rotation of the drum **28**, a temperature in the treating chamber **34**, an air flow through the treating chamber **34**, a type of treating chemistry, an amount of treating chemistry, a start or end of cycle condition and a start or end cycle step condition.

In addition to setting one or more parameters of a cycle of operation based on the determined load motion condition, the controller **14** may also use information received from one or more sensors **84**. For example, the controller **14** may use information relating to the motor torque to estimate the size of the load and set one or more operating parameters based on the estimated load size and the determined load motion condition.

FIG. **7** illustrates an example of a segmentation map **130** for a horizontal axis dryer **10** with the imaging device **70** located near the horizontal axis of the drum **28** on the rear bulkhead **30**, as illustrated in FIG. **4**. As illustrated in FIG. **7**, the image of the treating chamber **34** may be divided into 17 segments extending from the periphery of the drum **28** into the center of the treating chamber **34**. The location, number, shape and size of the segments may vary depending on a variety of factors, including, without limitation, the motion condition(s) being monitored, the shape of the drum **28** and the location of the imaging device **70**. While the grid **130** is illustrated having a generally circular shape, the captured image and applied grid are not limited to any regular or irregular shape.

FIG. **8** illustrates an example of an integrated segmentation map **132** for a clothes dryer **10** having a drum **28** rotating counter clockwise wherein the load is exhibiting a tumbling condition. The segmentation map **132** may be created by integrating the percent coverage in each segment of the image over time. The "x" in each segment symbolizes the percent coverage of the load in each segment; the larger and more numerous the "x", the larger the percent coverage. The "x" is used for visual understanding. However, in practice, the "x" may be a numerical value stored in the memory **80** of the controller **14**, with the magnitude of the numerical value indicating the percentage coverage in the corresponding segment.

As may be seen in the integrated segmentation map **132**, the load is spending most of its time at the bottom of the drum **28**, the middle of the treating chamber **34** and partly up the right side of the drum **28**. This percent coverage pattern is consistent with a tumbling condition for a drum **28** rotating counter clockwise, wherein the load may be lifted into the air by the rotation of the drum **28** and then falls back to the bottom of the drum **28**.

FIG. **9** illustrates a method **200** for obtaining the initial image data in step **104** of method **100**. The initial image is an optional step and may be used by the controller **14** to determine parameters of the load such as the size or fabric type of the load. The initial imaging method **200** may be executed by the controller **14** prior to the start of a drying or treatment cycle of the clothes dryer **10**.

The method **200** starts with assuming that the user has loaded the clothes dryer **10** with one or more articles to form the laundry load and closed the door **26**. The method **200** may be initiated automatically when the user closes the door **26** or at the start of a user selected operating cycle. The controller **14** first sets a counter Rotation Count to 0 in step **204**.

In the next step **206**, the controller **14** may capture an image of the load to determine the load parameters for completing the cycle of operation. The load parameters may be determined in step **208** and combined with load parameters previously determined from the image data or determined elsewhere in step **212**. For example, the cycle and parameter settings selected by the user through the user interface **16** may be combined with the parameters determined from the image data.

In the next step **214**, the controller **14** may determine if the rotation count has reached the target count. If it has not reached the target rotation count, then the drum **28** may be rotated one or more times and the rotation count is increased by 1 in steps **218** and **220**. The method **200** then starts again at step **206** and repeats steps **206** through **214** until the rotation count equals the target count in step **214**.

Once the rotation count reaches the target count in step **214**, the controller may estimate the load parameters for completing a cycle of operation in step **216**. Examples of load parameters that may be estimated using method **200** include the size of the load, fabric type and the color of the load.

FIG. **10** illustrates a method **300** for automatically determining the motion state of the laundry and controlling the operation of the clothes dryer **10** based on the determined motion state. The load motion condition may be determined in step **304** according to steps **104** through **126** of the method **100** or based on another method.

The determined load motion condition may be analyzed to determine if it corresponds to a condition of concern in step **306**. This determination may include taking into account other load conditions, such as the fabric type and load size, which may be determined using the method **200** or based on sensor readings from one or more sensors **84** associated with the dryer **10**.

If the motion state indicates a condition of concern in step **306**, the controller **14** may control the operation of the clothes dryer **10** depending on the determined condition to apply one or more corrective actions. The control of the clothes dryer **10** may include setting at least one operating parameter of a cycle of operation including a rotational speed of the drum **28**, a direction of rotation of the drum **28**, a temperature in the treating chamber **34**, an air flow through the treating chamber **34**, a type of treating chemistry, an amount of treating chemistry, a start or end of cycle condition and a start or end cycle step condition.

In step **306**, a condition of concern that requires corrective action may be based on determining an absolute or relative amount of the laundry load that is exhibiting a particular motion condition. This may include determining that a motion condition, such as sliding, rolling or satelliting, requires corrective action when any part of the laundry is exhibiting the condition. Alternatively, it may be determined in step **306** that a condition of concern exists only if all of the load is exhibiting the condition.

A predetermined threshold may also be set for a given motion condition wherein if it is determined that some part of the laundry load above the threshold is exhibiting a condition of concern, corrective action is taken. The threshold for determining when a motion condition requires corrective action may vary depending on the size and fabric type of the load, the determined motion condition, the cycle and one or more operating parameters of the cycle.

Once it is determined that a condition of concern requiring corrective action is occurring, a corrective action may be applied to the clothes dryer **10** in step **308**. A new load motion condition may be determined in step **310** to determine if the corrective action applied in step **308** had its intended effect. The new load motion condition may be determined in a manner similar to step **304** to determine whether or not the condition was corrected and a condition of concern requiring corrective action is no longer taking place.

If it is determined in step **314** that the condition was not corrected, the controller **14** may determine if other correction options are available and one or more of these options may be applied in step **308** and the process may be repeated until the condition is corrected. If it is determined in step **316** that no other correction options are available, the controller **14** may stop the operating cycle and notify the user using an audible signal or a visual signal through the user interface **16**.

Alternatively, the controller **14** may implement corrective actions until the condition is reduced to within an acceptable range. If the condition cannot be corrected or reduced to within an acceptable range, the controller **14** may notify the user of a condition requiring attention through an audible or visual signal, such as an indicator light on the user interface **16**, for example. The controller **14** may move to step **318** in the method **300** if all of the pre-determined corrective actions for a given condition have been tried, after a pre-determined number of corrective actions have been tried or after a pre-determined amount of time has elapsed since the condition of concern was identified in step **306**.

One example of a condition of concern that may be determined using the imaging device **70** is satelliting of the load. Satelliting may often occur when small loads are placed in the treating chamber **34**. When satelliting occurs, some or all of the items of the load do not tumble, but adhere to the wall of the drum **28** or the lifters **36**. As a result of satelliting, the items of the load may not interact with the air applied for drying the load or any other treatment such as a chemical or steam treatment. This may lead to incomplete and/or inconsistent drying of the load or non-uniform application of the treatment.

FIG. **11** illustrates an example of an integrated segmentation map **330** for a small load that may be determined using steps **104** through **126** of the method **100** illustrated in FIG. **6**.

The segmentation map **330** may be utilized according to the method **300** to determine if a condition of concern is occurring and appropriate corrective measures may be applied as illustrated in FIG. **10**. The "x" in each segment symbolizes the integrated percent coverage of the load in each segment over time; the larger the "x", the larger the percent coverage. As may be seen in FIG. **11**, the load is mostly located in the outer segments around the periphery of the drum **28**, consistent with satelliting of the load.

While the map **330** illustrates a satelliting condition in which all of the load is plastered against the periphery of the drum **28**, a range of satelliting conditions may exist ranging from a single item in the load to the entire load. For example, a single item in the load may be experiencing a satelliting condition while the remainder of the load is experiencing some other condition, such as tumbling, that may or may not require corrective action.

Alternatively, it may be determined that some relative amount of the laundry load is satelliting, for example, 15% of the load, while the remaining 85% of the load is experiencing a different motion condition. The threshold for determining the absolute or relative amount of satelliting that requires a corrective action may vary depending on the determined condition, the size and type of the load, the cycle and one or more operating parameters of the cycle.

As illustrated in method **300**, the controller **14** may control the operation of the clothes dryer **10** to affect one or more corrective actions in step **308** consistent with the determined satelliting condition. Examples of corrective action that may be taken to correct a satelliting condition include: slowing down the rotational speed of the drum **28**; stopping the rotation of the drum **28** and restarting the rotation in a reverse direction; stopping the rotation of the drum **28** and restarting the rotation in the same direction. The controller **14** may implement successive corrective actions until the condition is corrected or may notify the user if the condition cannot be corrected.

Another example of a condition of concern is rolling of the load. Rolling is a condition that may occur with large loads, such as bed sheets or blankets. Rolling is a condition in which the load is not lifted and tumbled by the rotation of the drum **28**, but rather the load stays near the bottom of the drum **28**. Rolling may result in the load not being dried completely or uniformly, which may lead to longer drying times. In addition, the load may become tangled, requiring the user to untangle the load and possibly restart the drying cycle.

FIG. **12** illustrates an example of an integrated segmentation map **340** for a load of laundry that may be determined using steps **104** through **126** of the method **100** illustrated in FIG. **6**. The segmentation map **330** may be utilized according to the method **300** to determine if a condition of concern is occurring and appropriate corrective measures may be applied as illustrated in FIG. **10**. The "x" in each segment symbolizes the integrated percent coverage of the load in each segment over time; the larger and more numerous the "x", the larger the percent coverage. As may be seen in FIG. **12**, the load is mostly located at the bottom of the drum **28**, consistent with the condition of rolling or balling up of the load.

The map **340** is just one illustration of a rolling condition. A variety of rolling conditions may occur, producing a variety of integrated segmentation maps. The controller software may be programmed to differentiate between the different possible rolling conditions and determine which rolling conditions warrant corrective action. The threshold for determining what amount of rolling requires a corrective action may vary depending on the determined condition, the size and type of the load, the cycle and one or more operating parameters of the cycle.

As illustrated in method **300**, the controller **14** may control the operation of the clothes dryer **10** to affect one or more corrective actions in step **308** consistent with the determined rolling condition. Examples of corrective action that may be taken to correct a rolling condition include: reversing the direction of rotation of the drum **28** and oscillating the direction of rotation of the drum. The controller **14** may implement successive corrective actions until the condition is corrected or may notify the user if the condition cannot be corrected.

Another example of a condition of concern is sliding. Sliding is a condition in which the laundry is not lifted by the lifters **36** as the drum rotates, but rather slide off the lifter **36**, exposing generally the same surface area as the drum **28** rotates. Sliding may result in the load not being dried uniformly, which may lead to longer drying times and non-uniform application of a treatment.

An integrated segmentation map may be determined using steps **104** through **126** of the method **100** illustrated in FIG. **6** to determine the existence of a sliding condition. The segmentation map may be utilized according to the method **300** to determine if a sliding condition of concern is occurring and appropriate corrective measures may be applied as illustrated in FIG. **10**. Examples of corrective action that may be taken to correct a sliding condition include: reversing the direction of rotation of the drum **28** and increasing the speed of rotation of the drum **28**. As illustrated by method **300**, the controller **14** may implement successive corrective actions until the condition is corrected or may notify the user if the condition cannot be corrected.

Another example of a condition of concern that may be determined using steps **104** through **126** of the method **100** is blocking of the air inlet **45** that fluidly connects the treating chamber **34** with the exhaust conduit **44**. Blocking of the air inlet **45** may lead to diminished air flow, longer drying times or incomplete drying of the load. The method **100** may be used to determine a segmentation map having segments corresponding to the positions in front of the air inlet **45**.

The segmentation map may be analyzed using the method **300** as illustrated in FIG. **10** to determine if the load is moving past the air inlet **45** or if one or more items of the load is stationary with respect to the air inlet **45** for some pre-determined length of time. If the controller **14** determines that one or more items of the load is stationary with respect to the air inlet **45**, the controller **14** may determine that the air inlet **45** is blocked and corrective action is required.

As illustrated in method **300**, the controller **14** may control the operation of the clothes dryer **10** to affect one or more corrective actions in step **308** consistent with the determined blockage condition. Examples of corrective action that may be taken to correct blockage of the air inlet **45** include: stopping the blower **46** while continuing to rotate the drum **28** and restarting the blower **46** when it is determined that the blockage is no longer present; or stopping both the drum **28** and the blower **46** and restarting both when it is determined that the blockage is no longer present.

FIG. **13** illustrates a method **400** according to another embodiment of the invention for determining an amount of tumbling in the clothes dryer **10** and setting the speed of rotation of the drum **28** to achieve a desired amount of tumbling. The amount of tumbling may be determined using steps **104** through **126** of the method **100** illustrated in FIG. **6**, or some other method. Tumbling may be a desired condition in a clothes dryer because it may lead to decreased drying times and more uniform application of a treatment.

According to method **400**, in step **402** the amount of tumbling may be determined according to method **100**, for example, by obtaining an integrated segmentation map. The integrated segmentation map may be analyzed using pattern recognition techniques or one or more functions to determine the absolute or relative amount of tumbling in the dryer drum **28**. For example, an absolute determination of load tumbling may include determining that all of the load is tumbling and a tumbling condition exists or that a tumbling condition does not exist if any part of the load is not tumbling. Determining a relative amount of tumbling may include determining an amount of the load that is experiencing a tumbling condition relative to the entire load.

The determined amount of tumbling may then be compared to a desired amount of tumbling in step **406**. The desired amount of tumbling may be determined automatically by the controller **14** based on the cycle of operation and/or one or more operating parameters. The operating parameters may be set by the user or determined automatically according to the method **200** or some other method. Examples of operating parameters that may be used to determine the desired amount of tumbling include the size and fabric type of the load.

If the determined amount of tumbling does not equal the desired amount of tumbling or does not fall within an acceptable range of a desired amount of tumbling, the speed of rotation of the drum **28** may be changed in step **408**. The speed of the drum **28** may be increased or decreased depending on the difference between the determined amount of tumbling and the desired amount of tumbling. For example, if the determined amount of tumbling is higher than the desired amount of tumbling, the speed of the drum **28** may be decreased.

Once the drum **28** reaches the new speed set in step **408**, an updated amount of tumbling may be determined in step **412** and analyzed to determine if the new amount of tumbling corresponds to the desired amount of tumbling. Steps **408**-**414** may be repeated until the determined amount of tumbling equals the desired amount of tumbling or falls within an acceptable range of desired tumbling. In this manner, the speed of rotation of the drum **28** may be controlled to provide the desired amount of tumbling for a given load of laundry based on conditions within the treating chamber **34**. The method **400** may be used one or more times throughout the course of an operating cycle to adjust the speed of the drum **28** to provide the desired amount of tumbling.

While the invention has been specifically described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not of limitation. Reasonable variation and modification are possible within the scope of the forgoing disclosure and drawings without departing from the spirit of the invention which is defined in the appended claims. For example, the sequence of steps depicted in each method described herein is for illustrative purposes only, and is not meant to limit the disclosed methods in any way as it is understood that the steps may proceed in a different logical order or additional or intervening steps may be included without detracting from the invention.

What is claimed is:

1. A method of operating a laundry treating appliance having a rotatable drum defining a laundry treating chamber according to an automatic cycle of operation, the method comprising:

imaging the laundry in the laundry treating chamber with an imaging device mounted to the laundry treating appliance and having a sensor operably coupled with at least a portion of the treating chamber during execution of the cycle of operation;

determining a motion condition of the laundry based on the imaging of the laundry; and

controlling the operation of the laundry treating appliance based on the determined motion condition.

2. The method of claim **1** wherein the imaging comprises taking at least one of a still image or a moving image.

3. The method of claim **2** wherein the imaging comprises taking both of at least one still image and a moving image.

4. The method of claim **1** wherein the imaging comprises digitally imaging the motion of the laundry.

5. The method of claim **1** wherein the sensor comprises at least one of a visible light sensor, an ultraviolet light sensor or an infrared sensor.

6. The method of claim **1** wherein the controlling the operation comprises setting an operating parameter of the laundry treating appliance.

7. The method of claim **6** wherein the setting the operating parameter comprises setting at least one of:

a rotational speed of the drum;
a direction of rotation of the drum;
a temperature in the treating chamber;
an air flow through the treating chamber;
at least one of a start and end of cycle condition;
at least one of a start and end of cycle step condition;
a rotational speed of an agitator;
a direction of agitator rotation; or
a wash liquid fill level.

8. The method of claim **1** wherein the determining the motion condition comprises determining an amount of one of rolling, tumbling, sliding or satelliting.

9. The method of claim **1** wherein the motion condition comprises at least one of rolling, tumbling, sliding or satelliting.

10. The method of claim **9** wherein the motion condition comprises any combination of rolling, tumbling, sliding or satelliting.

11. The method of claim **10** wherein the motion condition comprises a relative amount of any combination of at least two of rolling, tumbling, sliding or satelliting.

12. The method of claim **9** wherein the motion condition comprises determining a transition between any combination of at least two of rolling, tumbling, sliding or satelliting.

13. The method of claim **9** further comprising decreasing a rotational speed of the drum when at least a portion of the laundry is satelliting.

14. The method of claim **9** further comprising adjusting a rotational speed of the drum until the laundry is tumbling.

15. The method of claim **9** further comprising adjusting a rotational speed of the drum to control an amount of tumbling to a predetermined amount.

16. A method of operating a laundry treating appliance having a rotatable drum defining a laundry treating chamber according to an automatic cycle of operation, the method comprising:

imaging the laundry in the laundry treating chamber with an imaging device mounted to the laundry treating appliance and having a sensor outputting data representative of the image of the laundry in the laundry treating chamber;

receiving the data by a controller having memory in which is stored computer software for processing the data;

processing the data with the computer software to determine a motion condition of the laundry based on the data; and controlling the operation of the laundry treating appliance based on the determined motion condition.

17. A method of operating a laundry treating appliance according to an automatic cycle of operation, the laundry treating appliance having a drum defining a laundry treating chamber, with the drum being rotated at an adjustable set speed, the method comprising:

imaging the laundry in the laundry treating chamber with an imaging device mounted to the laundry treating appliance and having a sensor operably coupled with at least a portion of the treating chamber during execution of the cycle of operation;

determining whether a predetermined amount of the laundry is satelliting based on the imaging of the laundry; and

reducing the set speed when a predetermined amount of the laundry is satelliting.

18. The method of claim **17** wherein an amount of laundry that is satelliting is determined by determining one of an absolute amount and a relative amount of the laundry that is satelliting.

19. The method of claim **17** wherein the reducing the set speed comprises reducing the set speed to a point that reduces the amount of satelliting.

20. The method of claim **17** wherein reducing the set speed comprises reducing the set speed to a point that less than a predetermined amount of laundry is satelliting.

21. The method of claim **17** wherein reducing the set speed comprises reducing the set speed to a point when no laundry is satelliting.

22. The method of claim **17** wherein the set speed is reduced in one of discrete steps or continuously.

23. The method of claim **17** wherein the sensor comprises at least one of a visible light sensor, an ultraviolet light sensor or an infrared sensor.

24. A method of operating a laundry treating appliance according to an automatic cycle of operation, the laundry treating appliance having a drum defining a laundry treating chamber, with the drum being rotated at an adjustable set speed, the method comprising:

imaging the laundry in the laundry treating chamber with an imaging device mounted to the laundry treating appliance and having a sensor operably coupled with at least a portion of the treating chamber during execution of the cycle of operation;

determining an amount of tumbling of the laundry based on the imaging of the laundry; and

adjusting the set speed to control the amount of tumbling to a predetermined amount of tumbling.

25. The method of claim **24** wherein the predetermined amount of tumbling is set to maximize the amount of tumbling.

26. The method of claim **24** wherein the predetermined amount of tumbling is set to control an amount of mechanical energy imparted to the laundry.

27. The method of claim **26** wherein the amount of mechanical energy imparted to the laundry is a maximum amount of mechanical energy.

28. The method of claim **24** wherein the sensor comprises at least one of a visible light sensor, an ultraviolet light sensor or an infrared sensor.

29. A laundry treating appliance for treating laundry according to a treating cycle of operation, comprising:

a laundry treating chamber receiving laundry for treatment;

at least one component operable to implement at least part of the treating cycle of operation;

an imaging device mounted to the laundry treating appliance and having a sensor operably coupled with at least a portion of the treating chamber during execution of the treating cycle of operation and outputting imaging data representative of at least a portion of the laundry in the laundry treating chamber; and

a controller operably coupled to the at least one component and the imaging device, the controller configured to determine a motion condition of the laundry based on the imaging data and to control the at least one component to implement the treating cycle of operation based on the determined motion condition.

30. The laundry treating appliance of claim **29** wherein the at least one component is a rotatable drum defining the treating chamber and the controller is configured to control a rate of rotation of the drum based on the motion condition.

31. The laundry treating appliance of claim **30** wherein the at least one component further comprises a motor operably coupled to the drum and controller and the controller is configured to control the motor to control the rate of rotation of the drum.

32. The laundry treating appliance of claim **29** wherein the motion condition determined by the controller comprises at least one of rolling, tumbling, sliding or satelliting.

33. The laundry treating appliance of claim **32** wherein the motion condition determined by the controller comprises any combination of rolling, tumbling, sliding or satelliting.

34. The laundry treating appliance of claim **32** wherein the motion condition determined by the controller comprises a relative amount of any combination of at least two of rolling, tumbling, sliding or satelliting.

35. The laundry treating appliance of claim **32** wherein the motion condition determined by the controller comprises determining a transition between any combination of at least two of rolling, tumbling, sliding or satelliting.

36. The laundry treating appliance of claim **1** wherein the controller is configured to control at least one component to set at least one of:

a rotational speed of a drum defining the treating chamber;

a direction of rotation of a drum defining the treating chamber;

a temperature in the treating chamber;

an air flow through the treating chamber;

at least one of a start and end of cycle condition;

at least one of a start and end of cycle step condition;

a rotational speed of an agitator;

a direction of agitator rotation; or

a wash liquid fill level.

37. The laundry treating appliance of claim **29** wherein the sensor comprises at least one of a visible light sensor, an ultraviolet light sensor or an infrared sensor.

38. The laundry treating appliance of claim **29** further comprising at least one of the following sensors operably coupled to the controller and providing a corresponding input to the controller: a treating chamber temperature sensor, an inlet air temperature sensor, an exhaust air temperature sensor, a moisture sensor, an air flow rate sensor, a weight sensor, or a motor torque sensor.

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